CENTER BREAK SWITCH WITH REDUCED OPENING FORCE REQUIREMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to center break switches, such as for electrical power substations and transmission lines, and particularly to such a switch in an arrangement facilitating opening of the switch.

2. Background Art

Center break switches have (in a single pole) two switch blades with mating contacts that meet, and separate, between a pair of rotatable blade supports. In a common type, the blade supports include ceramic or polymer insulators that are generally cylindrical with lateral sheds. The supports are joined at one end (nominally, the "bottom") to a quite rigid metal base with a bearing for rotation of each support relative to the base and a mechanism for imparting rotational force to both supports, hence moving the switch blades into or out of a closed contact position. The supports, and their axes of rotation, are substantially parallel to each other in one switch type or, in another type, are in a substantially V-shaped configuration. Switches of interest include those described and illustrated in Cleaveland/Price Inc. descriptive bulletin DB-126A02, "Aluminum Center Break Switch", published in 2002, that is representative of prior art to the present invention.

Operation of such switches is in some cases manual (e.g., by a handcrank or a swing handle) and in some cases by electric motor. Whether manually or motor operated, it is desirable to operate the switch easily and quickly with only modest requirements on the equipment and personnel. For example, some switches have a handcrank operator for manual operation. The handcrank is connected to the rotatable

support apparatus through a gearbox with a gear ratio typically in a range from about 10:1 to 40:1, as specified by a user. A higher gear ratio allows a switch to be opened with less manual force but requires more time, which is generally undesirable.

Another factor in switch operation is that a typical installation has three poles, substantially alike, one for each phase of a three phase electrical system, and the operator must apply sufficient force to operate all three poles together. A maximum operating force, for three-phase switches, is typically specified to be in a range from about 35 to 70 pounds. Some installations have switches ganged together in even larger numbers, such as six poles with two poles for each phase of a three phase system.

Center break switches are now applied over a wide range of voltages, including high voltage systems up to a nominal rating of at least about 230 kV. Required switch size increases with increasing voltage (for contact clearance when the switch is open and for sufficient distance across the insulative supports) so that the rotatable supports and the contact blades reach up to several feet in length. This makes for a relatively massive structure to be moved and the longer supports make them more subject to bowing that can affect operation. In general, however, considerations affecting the opening force requirements apply to some degree regardless of the switch size or the number of switches operated together.

Switches operate in a variety of environments including those that can, particularly with age, change the amount of required operating force. One type of known switch has contacts with engaging surfaces that meet substantially in a horizontal plane like that of the arcuate motion of the contacts resulting from blade supports' rotation. This produces considerable wiping action between the contacts during opening and closing that helps keep the contact zone free of debris and oxides. In this respect, sliding friction between the contacts enhances switch performance while also having an influence on the required opening force.

A variety of contact configurations are used in various center break switches. For example, some have appreciable contact engagement in a vertical plane that is substantially perpendicular to the plane in which the blades move. Still, in any of the contact configurations, there is some degree of sliding friction that can affect switch opening. Prior art has largely relied on a basic assumption that the axes of rotation of the

insulative supports are substantially fixed. While prior center break switches have been generally successful, their design has not addressed the fact that sliding friction between the contacts during a switch opening can alter the location of the axes of rotation of the supports, particularly, but not limited to, those of larger units. Altering the axes of rotation by contact friction results in greater required force and time to separate the contacts than if those axes were fixed.

SUMMARY OF THE INVENTION

The present invention takes into account the effects of friction, including possible bowing movement of the support axes, and provides a simple arrangement for facilitating switch opening despite such friction effects.

Without friction, a center break switch would open very easily with no forces to distort the axes of rotation of the supports. With the switch blades at fixed support axes, the blades would swing the contacts from a fully closed position to a point of separation while only traversing a minimum distance. However, friction between contacts can change that by introducing a drag effect altering the geometry.

Sliding friction between contacts can cause the points of rotation of the blades, at the upper end of their supports, to move toward each other due to bowing of the insulative supports. This is because the contacts generate forces to overcome the sliding friction so that during the time contact motion has begun, but the contacts are still not separated, the contacts are not moving in a perfect arc. Their separation will only occur a distance beyond the minimum distance referred to above. With that change, the required torque and operating force is increased. Also, somewhat more time is required.

Now, in one embodiment of the present invention, a fulcrum mechanism is combined with the switch elements that may be like the prior art in other respects. It can include two additional members, such as bars (sometimes they may be referred to by alternative expressions such as pry bars, pry-open bars, pry-out bars, pivot bars, easy open bars, or open-assist bars) that are added in combination with typical center break switch of the prior art. The "bars" need not be very elongated and can be any members that abut each other as described below during a switch opening. The elements of the

fulcrum mechanism can be members attached to the respective blades or elements integral with the blades.

The bars are, in one example, relatively flat, stiff, metal plates, approximately “L” (or backward “L”) shaped. One bar is on each switch blade, e.g., with the bottom of the “L” (or backward “L”) bolted to the blade behind the contact on that blade and the upper parts of the bars extending beside the contacts to face each other. The facing portions abut and contact each other during a switch opening along with initial contact movement and before full separation. That is, the upper parts of an “L” on a right side blade and the upper part of a reverse “L” on a left side blade are located behind the contacts (with respect to the direction the contacts move) and the ends of the “L” and reverse “L” bars, which have some width and thickness, possibly with a flange-like end, meet to produce the intended effect.

While the contacts are engaged in sliding friction, the bars provide a new pivot point, or axis of rotation, during the opening motion that pries the contacts apart and forces them to stay on a more perfect arc as they open. The bars reduce bowing movement of the insulator supports and provide a contact parting at a point substantially like one that would exist if there were no sliding friction, even though the contacts do experience the same friction and wiping action.

The bars can be simply formed with the shape mentioned just as an example. Their conductivity is not an issue as far as producing the effect described. They need not touch in the fully closed position and need not have any direct contact with the switch contacts. (If the bars are metal, it is generally preferred to avoid any such contact.) They can be arranged to stay clear of any auxiliary switch elements near the contacts, such as arc horns, and may be attached at any convenient location along the blades, including at the same bolt locations arc horns are attached. Fortunately, the bars assist appreciably in an opening operation without interfering with a switch closing. They can be arranged to have little or no contact with each other during a closing operation and not appreciably alter the closing force.

The earlier contact release point that is achieved appreciably reduces the required operating force. A prototype test on a 230 kV, 3000 ampere switch showed a reduction in operating force on a handcrank gearbox (having a gear ratio of 20:1) from

about 40 pounds without the bars to about 15 pounds with them in place, with the same contact pressure. Such switches have insulative supports over seven feet long and switch blades with a radius of about five feet.

The arrangement can be economical, effective, and readily implemented on switches already in service. It provides a convenient alternative, or a complement to other approaches that could be taken, such as providing a higher ratio gearbox for a handcrank operator.

Ancillary benefits include an opportunity to have higher contact pressure because the pry bars alleviate concern that less pressure should be maintained for easier opening. Also, flexibility of insulators can be less of a concern, so they can possibly be made from a wider range of materials.

These and other aspects of the present invention will be further understood from the following text and drawings.

BRIEF DESCRIPTION OF THE DRAWING

Figures 1 and 2 are, respectively, side elevation and top plan views of a center break switch showing an embodiment of the invention where Fig. 2 omits for clarity elements of Fig. 1 below a top portion;

Fig. 3 is an enlarged plan view of part of the switch of Figs. 1 and 2;

Fig. 4 is an elevation view of the parts shown in Fig. 3;

Fig. 5 is a plan view of the apparatus of Figs. 3 and 4 during movement from a fully closed position;

Fig. 6 is a schematic plan view of three mechanically interconnected switches;

Figs. 7 and 8 are partial plan views of two alternative embodiments; and

Figs. 9 and 10 are, respectively, partial plan and elevation views of a further embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Figs. 1, 2, 3, 4, and 5 are of the same apparatus although some elements are shown only in Fig. 1. While each of Figs. 1, 2, 3 and 4 show a fully closed switch position, Fig. 2 also shows a position after contact separation.

Fig. 1 shows a switch (one-pole) with a rigid base 10, e.g., of hot-dip galvanized steel, on which moveable elements of the switch are mounted. Rotatable supports 12 and 13 are mounted at their bottom ends with bearings (not shown) for their rotation relative to the base 10. In this example, the supports 12 and 13 each include a respective stack of insulators 12a and 13a with intermediate metal couplings 12b and 13b. The insulators 12a and 13a are generally of a polymer (e.g., fiber reinforced plastic) or a ceramic material. Even though they are not intended to flex, the insulators are subject to some inherent flexing due to the described friction effects.

Contact blades 14 and 15 are respectively joined to the upper ends of supports 12 and 13 (Fig. 1). Near the supported ends of the contact blades 14 and 15 there is a respective one of a pair of line terminals 20 and 21 for connection with a conductor of an electrical system. Features for pivoting of the blades 14 and 15 in relation to the relatively fixed terminals 20 and 21 are included but will not be detailed herein and may be the same as prior art. The blades 14 and 15 have ends away from the supports 12 and 13 with blade ends, contacts and members to assist in switch opening (to be discussed later) in an assembly identified collectively by reference numeral 50 in Figs. 1 and 2 with more detailed identification of the elements in the subsequent enlarged views.

The blades 14 and 15 are, for example, each a single piece, aluminum, square tube. Each blade 14 and 15 has one of a pair of switch contacts 16 and 17 at its end opposite its respective support 12 or 13.

In this example, as shown in Figs. 3 and 4, the left side contact 16 includes four pairs of conductive fingers: two upper pairs each having a top finger 16a and a bottom finger 16b and two lower pairs each having a top finger 16c and a bottom finger 16d, all of which are conductively joined near their left ends to the blade 14.

The right side contact 17 includes a pair of conductive stabs 17a and 17b, both conductively joined near their right ends to the blade 15, that are respectively captured (in the closed position) within a jaw formed by the upper pairs of contact fingers 16a and 16b and within a jaw formed by the lower pairs of contact fingers 16c and 16d. The elements of contacts 16 and 17 are highly conductive, e.g., silver plated or silver overlaid copper.

In addition, there is a contact pressure adjusting mechanism 18, such as one supported from the blade 14 with bolts and adjusting nuts bearing on spring plates that bear against the fingers of contact 16.

The figures omit for greater clarity corona or arc reducing spheres or horns, and also an ice shield, that are conventionally arranged near contacts of such a switch as that shown.

At the bottom of the switch (Fig. 1) a mechanism 30 is provided for operation of the switch including a tie rod 31 mechanically coupled to both insulative supports 12 and 13 at metal flange members not detailed here. Bearings (not shown) for rotation of the supports 12 and 13 relative to the rigid base 10 are located near the attachments of rod 31.

In this example, the mechanism 30 further includes a handcrank 32 schematically shown in a mechanically coupled relation through a gearbox 33 to the tie rod 31 that transmits rotational force to the supports 12 and 13, both together and also typically together with force transmitted to two other switch poles of the same nature, as is later discussed in connection with Fig. 6.

All of the elements discussed so far (not including any open-assist members 40 and 42 as described below) may be in accordance with known prior art switches such as, but not limited to, that described in the above mentioned background publication which is incorporated by reference herein for further description of examples of the construction and use of such switches, including both those with substantially parallel rotatable supports (as shown here) and those with substantially V-oriented supports (not shown herein) with otherwise similar features.

While the invention is not so limited, the contacts 16 and 17 in this example have fingers and stabs that engage each other in one or more planes parallel to

the arcuate movement of the blades 14 and 15; a substantially horizontal interface. (Fig. 2 gives a general picture of the blades and contacts as they have been moved from a closed to a contact parted position by rotation at their supports.) The contact fingers 16a-16d are not totally planar, since (as shown in Fig. 4) they have a bend that makes the principal direct contact with the stabs 17a and 17b along a line 52 (in the closed switch position). Before the switch reaches a position as shown in Fig. 2, those bends of the fingers move over the surfaces of the stabs with a wiping action that is favorable for good conduction. The contact pressure adjustment mechanism 18 allows a user to set the pressure to a desired level.

(For general reference, switches of the type described typically go to a fully open position only after the blades have turned 90°. In views such as Fig. 2, the contacts have parted and have no more frictional engagement but the blades have not yet reached the fully open position.)

Figs. 3 to 5 show a contact assembly 50 that, in addition to the elements that may be otherwise conventional, include a pair of plate-like bars 40 and 42 that are shown respectively attached (e.g., bolted) near a first end 40a and 42a to the top of a switch blade 14 or 15 and shaped to extend in front of the contacts 16 and 17 to face each other at their ends 40b and 42b that may have small flanges, as shown.

The bars 40 and 42 need not make physical contact to each other in the fully closed position of the switch, so a gap may occur as shown in Fig. 3. (The "facing" relation is meant to include either with or without a gap). The bars 40 and 42 assist in switch opening. When blade rotation and contact movement has started, the bars 40 and 42 meet at at least part of their facing ends 40b and 42b (e.g., edge corners 40c and 42c as shown in Fig. 5) and establish there a new pivot or axis of rotation that facilitates switch opening. The line (or plane) 52 of principal contact engagement and wiping action shifts as the blades move in the directions of the arrows in Fig. 5.

Now, instead of contact sliding friction causing bowing of the supports 12 and 13 so the switch opening is delayed due to extra travel of the contacts 16 and 17 and requires more force, the locus of the pivot corners 40c and 42c stays substantially fixed through the duration of their contact to each other despite the contact friction.

By way of further example, the bars 40 and 42 are relatively stiff metal plates that are relatively flat although Fig. 4 shows a small angular variation and the abutting ends 40b and 42b have small vertical flanges. These bars are, looking in the plane of Fig. 3, respectively substantially L-shaped (bar 42) and reverse L-shaped (bar 40) with the bottom leg of each "L" joined at 40a and 42a to the respective blades and the ends of the top parts of the "L" configurations being the facing ends 40b and 42b.

One factor making it convenient to attach the bars 40 and 42 to the blades as shown is that the bar ends 40a and 42b can be bolted to the blades at bolt locations as shown that are the same as those used for attachment of arc horns (which are not shown in these views). This is particularly convenient for putting the assembly together on switches already in the field. A variety of other attachment locations and shapes for members performing the function of bars 40 and 42 will be apparent.

Fig. 6 illustrates a three phase switch combination with respective switches 61, 62 and 63 that can each be like that previously described. This schematically shows how a single mechanical arrangement 130 combining tie rods and related parts of each of the three switches are joined together for common operation from a single motive power source, e.g., a handcrank 132 and gearbox 133. This is a common situation and is shown to make the point that the inventive combination has further benefit when practiced in multi-switch gangs where opening force requirements are greater than with a single switch.

The described embodiment is also one that has the facing ends 40b and 42b that form the pivot point or axis, where corners 40c and 42c meet per Fig. 5, off of the line 52 of the main contact pressure. This is just one possible location. A general characteristic of the inventive combination is that members comprising the fulcrum mechanism, such as bars 40 and 42, meet and make a pivot point for the blades 14 and 16 at least some part of the time the contacts 16 and 17 are sliding together during a switch opening. Preferably, but not necessarily, the fulcrum mechanism is such that its pivot action occurs substantially throughout the sliding engagement of the contacts. Some benefit can be obtained even if it occurs only part of that time, for example during early contact movement. After the contacts have parted, the fulcrum mechanism need not operate.

Fig. 7 shows an alternative arrangement 150 for pivot members or bars on a switch with other elements as previously described. In this embodiment, the configuration of the blades 14 and 15 and the contacts 16 and 17 is the same as was previously described. The contacts 16 and 17 have a horizontal interface and move in the same direction as the contacts of Fig. 5. However, now pivot members 140 and 142 are attached to respective contact blades 14 and 16 on the side of the blades toward the front of the switch (considering a view such as that of Fig. 1) near their ends 140a and 142a,. The members 140 and 142 are plate-like bars that, in this example, are shown just flat and their ends 140b and 142b face each other, with a small gap in the closed position. As shown, bars 140 and 142 are equal in length; in general, they can have the same or different shape and size as long as their locations cause the described pivot action. In Fig. 7, as the switch opens, with blade movement as shown by the arrows, the pivot axis will occur at rear (or lower in the drawing) corner edges 140c and 142c, substantially as it does in the embodiment of Fig. 5. Fig. 7 represents just one alternative form a fulcrum mechanism can take with contacts having horizontal engagement.

Fig. 8 shows a further alternative. A fulcrum mechanism comprises elements 140' and 142' that are respectively integral with the blades 14' and 15'. For example, blades in the form of square tubes can have three sides partly cut away leaving portions 140' and 142' extending from the full square configuration. The extended material can be formed as desired, such as to form the illustrated flange portions at 140b' and 142b' that face each other and whose back corners 140c' and 142c' initially engage to provide a pivot as the contacts open.

A variety of contact arrangements for center break switches are used in the art other than that shown for contacts 16 and 17. Some have principal contact engagement and a degree of wiping action that is not in a plane parallel to the arcuate blade movement. For example, the contact faces may principally engage in a substantially vertical interface plane. Even so, to the extent the contacts engage with sliding friction in any of these alternative contact configurations, the present invention can be beneficial to facilitate switch opening.

Figs. 9 and 10 show an example of a combination 250 of pry bars with a pair of contacts with a vertical interface. Blade 214 supports a first contact 216 that has a

loop forming a jaw within which a stab-like second contact 217 on blade 215 is engaged. A closed switch is shown. The arrows in Fig. 9 show the directions the blades 214 and 215 will take during a switch opening. During that movement, front and back fingers of contact 116 slide against front and back ends of contact 217 and produce sliding friction.

The combination 250 includes pry bars 240 and 242 that are arranged and operate in substantially the same way as bars 40 and 42 previously described. Here the bars 240 and 242 are merely flat from their secured ends 240a and 242a out to their facing ends 240b and 242b at which a small vertical flange occurs. Also, it will be noted the bars 240 and 242 will meet and pivot, at the back corners 240c and 242c, along the same line as that on which the contacts engage in the closed position.

It is, therefore, apparent that the invention applies either in the case in which the contacts engage with sliding friction in a plane orientated the same as the plane of the movement of the blades or the case in which the plane of contact engagement is perpendicular to the blades' plane of motion. Also, it can be understood that the contacts can be configured with elements such that they engage, and slide, in both planes.

Among the considerations for members in the fulcrum, or open-assist, mechanism is to make any gap between them in the closed position as small as reasonably attainable so the pivot action can commence promptly upon contact movement. The gap can be avoided entirely although it is not generally preferred to have any conduction across the bars, if of metal, when closed. However, the bars need not be metal but may instead be of an insulative material such as fiber reinforced plastic, at least at the facing ends, so direct contact when closed would not be a concern.

The illustrated embodiments have a geometry for the open-assist elements with a pivot axis centered in relation to the blades and the blade supports although the contacts have a line of primary engagement, as shown in Figs. 3, 7, and 8, not quite centered between the ends of blades 14 and 15 or 14' and 15'. Symmetrical elements 40 and 42, 140 and 142, and 140' and 142' are generally preferred for typical switches, such as those with equal length blades. Variations can be implemented in which the abutting elements are not symmetrical; in general, they can have the same or different shape and size, and the same or different relative locations on the blades, as long as they meet to perform the described pivot action during the sliding engagement of the contacts.

While the description sometimes refers to “upper”, “lower”, “top” or “bottom”, “horizontal” or “vertical” orientations (consistent with the Figures), it will be understood the described switches can be mounted in essentially any orientation.

The specific embodiments disclosed are merely some examples of the various ways in which the invention can be practiced.